RESEARCH MANAGEMENT

A PUBLICATION OF THE
INDUSTRIAL RESEARCH INSTITUTE

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ABOUT THIS ISSUE

Small business and not-so-small business came together in March of this year to compare notes on the subject of research and development; the occasion was a Symposium on Industrial Research sponsored jointly by the Industrial Research Institute and the Young Presidents' Organization. Four papers from this Symposium have been selected for publication in this issue.

In the first paper, Lyle M. Spencer counters the small businessman's usual objections to research that are characteristically phrased in such words as, "Who needs it?," "What's in it for me?," "OK for big business but not for me," and concludes that successful research techniques are not beyond the reach of small business. He writes from wide experience as President of Science Research Associates, Inc., a firm that has provided consulting research services for many small businesses.

The second paper discusses sources of research and development assistance that are available to the small businessman outside his company—and, for that matter, are available also to big business if needed. The article on "Make-or-Buy Decisions" in our Winter 1958 Issue discussed the desirability of such extramural research assistance from a related point of view. The present paper is by Charles N. Kimball, President of Midwest Research Institute, one of the regional nonprofit research organizations that form one of the major categories of sources of outside research assistance about which he writes.

Charles L. Fleming, Jr., Vice President of Esso Research and Engineering Co., one of our largest industrial research organizations, in the third paper discusses basic principles of research organization and program planning that are equally applicable, he as-

serts after careful study, to both large and small business. He shows the importance of knowing what kind of projects should be undertaken and what can be expected from their solution. He stresses that the research director must have an adequate technical background, must have visioh, must be able to organize, and must be a salesman of research.

The concluding one of the group of papers from the IRI-YPO Symposium is a down-to-earth discussion of typical research costs. In it, Gerard C. Gambs has cited specific figures taken from many sources including the experience of his concern, the Consolidated Coal Co., and research surveys in the Pittsburgh area. Budgeting, accounting, and control techniques for research operations are reviewed briefly.

Finally, we present two contrasting papers from an Industrial Research Institute Study Group held in New York City in February 1959 on the subject, "Job Status as an Award for Scientific and Administrative Accomplishment." Although a superficial contact with these papers might leave the impression that they are diametrically opposed, we believe that a full understanding of them will show that they are both presentations of basically the same body of sound research principles, corresponding, however, to different points of view. Some will find more wisdom and help in one of these papers; others, we believe, in the other paper. The first one is by I. Goldman of Sylvania Research Laboratories; it emphasizes the uses of job descriptions and asserts that they should be broadly expressed if the job is broad. The second paper is by Frank D. Leamer, Personnel Director of the Bell Telephone Laboratories. It discusses the advantages of broad job classifications and points out some of the difficulties that arise when job classifications are unwisely made. We think that the reader will find it instructive to compare Mr. Leamer's views on the "technical ladder" technique with the article by Herbert A. Shepard entitled "The Dual Hierarchy in Research" which appeared in our Autumn 1958 Issue.

THE PLEASURES AND PAINS OF SMALL-BUSINESS RESEARCH*

LYLE M. SPENCER

President, Science Research Associates, Inc., Chicago, Illinois

Today, when our nation's business outlook is charged with so many dynamic possibilities, it is difficult to envision economic progress without conjuring up the genie of research. However, many businessmen do not yet associate progress with research; for some, there are attitudes of indifference or distrust or fear. To an overwhelming number of corporate executives, the research scientist appears to be the twentieth-century reincarnation of the medieval alchemist who sought to transmute base metal into gold by some elaborate abracadabra.

The leaders of the largest American corporations have explored systematically the tantalizing prospect of scientific tomorrows. The eminent Harvard economist, Sumner Slichter, has labeled the object of this new dedication of our large business leaders "The Industry of Discovery."

The American businessman, unlike many of his counterparts in Western Europe, often has had difficulty realizing this changing fact of scientific life. One reason for this is that many American businessmen have a time scale that is different from that of Euro-

* Presented at the Industrial Research Institute–Young Presidents' Organization Symposium on Industrial Research, New York, N.Y., March 2–3, 1959.

pean businessmen. This is apparent in the time the American allots to lunch, to reading, and to plannning: he is in a hurry.

Similarly, he has characteristically equated business success with a quick pay-off. His primary purpose is to reduce the time lag between the test tube or slide rule and the hula hoop or tail fin. He is slavishly committed to quick yearly results—even if these are superficial or gaudy. He is dominated by the annual report, the annual budget, the annual changeover. He has little patience to wait for the lonely experimenter or the cantankerous tinkerer—to say nothing of the interdisciplinary research team—to discover or devise a new synthetic textile or an electronic safety device for fast highway traffic. He hankers for innovations that show up at the cash register today—or at the latest, tomorrow.

Most American businessmen are, nevertheless, aware of the fantastic business results accruing from well-conceived research. In 1949, I am told, there was only one wholly synthetic fiber of consequence—nylon. Today, whole industries have been transformed by the development of an astonishing variety of synthetics, and many more are still to come. The tranquilizers were first reported in medicals journals in 1954, and within three years had been gobbled like gumdrops by at least twenty million Americans—with precisely what consequences no one yet knows.

While conditions vary enormously from one industry to another, a realistic estimate is that more than 50% of the sales of large manufacturing companies now stem from products that did not exist before World War II. In the past five years alone, sales of electronic computing "brains" have multiplied from $50 million to $300 million. Today's growth industries, as anyone riding the stock-market crest will attest, are those that pursue aggressive, well-planned R & D programs.

The statistics might lead one to think that almost every American company had adopted an R & D activity in the last few years. Between 1953 and 1957, for example, industry's R & D expenditures nearly doubled, increasing from $3.7 billion to $7.3 billion; presently, these expenditures are about $9 billion a

year. Remarkably enough, a little more than a half century ago, there was not even one commercial research laboratory in existence in the United States.

Despite this dramatic growth, the fact is that only about 11% of manufacturing companies with more than 50 employees have any kind of systematic research program. The five annual studies that my company, Science Research Associates, Inc. conducted for the Young Presidents' Organization (YPO) revealed that fewer than 12% of the 1,200 YPO firms had any real R & D program. YPO companies are fairly typical, I believe, of relatively small and middle-sized businesses in America. These YPO businesses, I might point out as a frame of reference, had an average net worth of $1.2 million in 1958 and a sales volume of about $4 million. The average number of employees last year was about 260; only 5% had more than 2,000 workers.

Small businesses and their bosses, as represented by YPO companies and their young executives, then, have largely ignored R & D programs. When we asked YPO members about research, their first reactions were likely to be defensive: "Who needs research?" or "What's in it for me?" or "Research is all right for the big company, but it doesn't fit a little guy like me." One quoted with remarkable candor Tom Lehrer's record: "Plagiarize—plagiarize—plagiarize—But always *call* it research."

At the outset, most small businessmen have built some mental blocks or barriers to R & D. Like people everywhere, they are apt to base their business decisions on beliefs or stereotypes that Walter Lippmann has called "the images in men's minds." Meetings such as the one held by the Young Presidents' Organization and the Industrial Research Institute at which this paper was first presented can, I hope, go a long way toward overcoming these misconceptions. Here are four of the most typical attitudinal barriers.

1. Few small businessmen understand the dynamic importance of R & D in maintaining, let alone improving, their competitive business positions. Dr. Slichter, for one, has observed that technological innovation is itself a powerful force in making people spend more of

their earnings and savings for new and attractive products and services. Therefore, he has pointed out, American business must be eternally devoted to discovery, regardless of the cyclical rhythms of prosperity and recession. While most economic theorists seem to agree on the need for continuing technological discovery, there are a few who believe business may dump too much money into research. Businessmen today feel somewhat like Sir Winston Churchill, who complained that whenever he asked Britain's *three* leading economists for an opinion, he received *four* replies—two of them from John Maynard Keynes.

2. *The financial risk of research is too great and the results too uncertain for the small businessman to take the gamble.* The risks of many research programs are high indeed. They are likely to be highest in new-product development, a good deal lower in distribution research, and possibly lowest in cost-cutting operations. One recent study by Booz, Allen, and Hamilton of 120 major industrial firms indicated that even the most successful companies had a 50% rate of failure in new-product development, while for the average firm only one out of every three projects were what could be called successful. The National Science Foundation has estimated that the average cost of a research specialist is of the order of $27,000 a year. One larger management consulting firm has advised its clients against setting up their own R & D division unless they are prepared to spend at least $100,000 a year for five years before expecting a profit pay-off.

3. *Most small businessmen are too busy with operating and financial problems to spend the time necessary for planning effective R & D programs.* Our SRA study of the YPO found that young presidents were occupied primarily with financial, sales, and personnel matters, in that order of emphasis. Where R & D programs had been set up, they were usually inspired by the action of competitors; thus, R & D was more often than not a reaction rather than a dedication. R & D was usually far down in the list of major goals of YPO firms. Moreover, small businessmen feel that they are at a distinct disadvantage when they seek funds to finance growth. Many feel

that they face an agonizing dilemma: they cannot really grow large unless they invest in R & D, but their finances do not permit them to do so.

4. Despite the admitted importance of R & D, small businessmen usually do not know how to plan, staff, or run such a program. An essential feature of successful research programs is their integration with long-range company planning. Most small businessmen don't really do much planning. Beset with a host of urgent day-to-day problems, most small business executives are forced to cope with immediate matters. Furthermore, most successful small businessmen are "doers" and "get-things-doners" rather than "egghead" thinkers or planners. The average YPO executive spends 80% of his day in face-to-face relations with other people, smoothing ruffled tempers, wrestling with sales crises, or plodding through production chores. These tasks leave little time for the daring, adventurous daydreaming essential to corporate planning and for creating R & D programs.

Also, the nature of the small businessman himself often militates against R & D. Many small businessmen who own their own firms possess a fierce desire to retain absolute control of the company. For some, there is no essential difference between their own personal security and the long-run welfare of their business. In one sampling of 60 small companies in which the chief executives were asked their views about carrying out expansion programs which required outside capital that would reduce direct ownership below the 51% mark, all but seven said they would be unwilling to initiate such programs. This attitude is markedly different from that of the professional executive who expects to be judged in a publicly-owned firm by his ability to keep sales and earnings growing.

Sometimes the small business resistance to the progress implicit in R & D springs from other psychological motivations. The gallery of small businessmen certainly contains these rogues.

1. The lazy president who doesn't really want his business to grow because he would have to devote more time and energy to it.
2. The authoritarian president who by temperament cannot permit his company to grow beyond the size where he personally can dictate every decision.
3. The maverick president who harbors the notion that his own business genius is responsible for his company's progress and that it is ridiculous to seek help from consultants and scientists.

While the preceding discussion of attitudinal barriers may sound pessimistic for the future of R & D in small business organizations, I do not intend to leave the impression that successful research techniques are beyond the reach of small businesses. Indeed, I believe there are many inviting ways in which profitable research programs *can* be organized, despite the barriers I have mentioned.

In our work at SRA with small business, we have encountered scores of alert executives who now use research imaginatively and inexpensively. The National Science Foundation has found 12,000 companies employing fewer than 500 workers that either conduct R & D programs of their own or finance such work by outside organizations. I strongly suspect that careful analysis of such cases and widespread publicity about their successful techniques may cause other small businessmen to say: "Maybe there is something to this research idea after all; I think our company *could* do *that* sort of thing."

In this connection, our psychologists have come up with some theories about basic personality differences among businessmen with regard to research: the innovator boss, for example, who likes to experiment with new ideas and devices versus the conformist boss, whose first reaction to any new suggestion is to give an array of reasons why it probably won't work. After all, the innovative or research approach to business *is* basically an attitude of mind. Beneath all the professional jargon, it really represents a positive

dissatisfaction with things as they are—the belief that no matter how good a product is today, it can be made better, or a discovery can provide a superior product to replace it.

Small businessmen who believe in R & D and use such programs successfully exhibit a number of attitudes in common.

1. They regard research as essentially an orderly method of collecting and organizing the necessary facts about a problem, to help them predict which new products or distribution methods are most likely to increase their sales and profits.
2. They believe that research helps them understand which factors in each of their company projects make it a success or a failure. Parenthetically, I may add that this aspect of research and development may concern itself with men as well as machines.
3. They look to research as an experiment before they assume a full-scale program of production. Thus, they expect to sharpen their executive judgment and select, with minimum risk, the products and programs which will pay off best.
4. They encourage the bold, creative people in their own offices and shops to dream daring dreams in the hope that useful innovations or discoveries may result.

One astute businessman has summarized the case for research about as well as I've ever heard it stated when he said: "All of us think we personally possess common sense and practical judgment. We *must* have this faith in ourselves in order to run our businesses. But sensible research helps more than anything else that I know to separate our prejudices and predilections from what the customer really *wants* to buy and *will* buy."

In conclusion, it is apparent from our studies of the attitudes and behavior of small businessmen that there are many pleasures as well as pains in research programs. Some research techniques, however simple, can be applied successfully to nearly *all* types of

small business. The tremendous explosion of knowledge in both the physical and the biological sciences in the past generation represents the main route to progress and affluence in the next generation. As Dr. Karl Menninger has so cogently stated: "The aspiration to improve is the most vivid evidence of the spiritual nature of man."

RESEARCH AND DEVELOPMENT ASSISTANCE FOR SMALL BUSINESS OUTSIDE OF THE COMPANY*

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The purpose of this paper is to describe the ways in which a small businessman can make gainful use of research and development facilities and talents available outside his own company. R & D, particularly for the small business, is not limited to basic or applied research, but includes a number of activities which larger businesses might not call research but which represent real technological problems for small business. These include improvements of present products, marketing, and such applications of technology in the manufacturing plant as quality control, better inspection techniques, improved materials handling, proper packaging of products, elimination of waste, and cutting of overall costs. All of these problems are largely technical in character.

One of the conclusions of the President's Conference on Research and Development for the Benefit of Small Business, which was held in Washington in September 1957, was that small business, at its present stage of understanding and use of R &D, has more need for the results of research than it has for research itself. That is, small business needs to comprehend and to use tech-

* Presented at the Industrial Research Institute–Young Presidents' Organization Symposium on Industrial Research, New York, N.Y., March 2–3, 1959.

nology, which is the result of research. It needs to recognize technology as a business tool, just as it recognizes and uses telephones, accounting systems, lathes, and typewriters as business tools.

In a survey in which several hundred people were interviewed throughout the country prior to the September 1957 President's Conference, the small businessmen in the group rated R & D as last among the five most pressing management problems which small business faces. On the other hand, the large business representatives in the group surveyed considered R & D to be the most important problem of small business.

Until 10 or 20 years ago, most of the research and development in this country was performed in the laboratories of large industrial companies or of government agencies. In recent years, the great national boom in research and the need for more technical manpower and more efficient technical effort has given rise to a considerable growth in outside research facilities, particularly those of organizations engaging in contract research. Many of these research groups are of assistance to businesses of all sizes and to the government as well, because of their ability to bridge the technical gaps existing between government, industry, and universities. Contract research groups are, of necessity, extremely flexible. They are staffed and equipped in ways which permit them to work on a wide variety of problems. This is a prerequisite, for they can rarely predict the nature of the technical demands to be made upon them.

Between $8- and $10 billion are spent annually on R & D in the United States. About half of this research is financed by Federal funds, the remainder principally by large industry. Of the total $8–$10 billion, between 5% and 10% is "farmed out" to contract groups.

There are five categories of outside technical assistance available to the small company which should be considered.

1. The first group to be considered comprises the *commercial testing laboratories.* There are hundreds of these in the United

States; many of them are listed in the yellow pages of the telephone book in almost every principal city. These laboratories usually are quite small, but they provide a variety of technical services. They can help small business with problems involving quality control, inspection, and technical production matters. Some of these testing laboratories also do product and process development. This type of outside facility is often the initial point of contact between the small businessman and science, and in this respect the testing laboratories serve a very useful introductory purpose.

2. The second category consists of the *independent consulting laboratories*. About 1,000 of these laboratories are described in a booklet prepared last year by the National Science Foundation entitled, "Directory of Independent Commerical Laboratories Performing Research and Development." Arthur D. Little, Inc., Foster D. Snell, Inc., and United States Testing Company are three of the larger groups in this field. These laboratories maintain competent staffs and adequate equipment to do research and development on a professional service basis. They thus serve as a supplement to the technical and management thinking of their clients. All work is carried out on a confidential basis, no competing projects are undertaken, and patent rights are invariably assigned to the client. Such consulting laboratories constitute the entire research facilities of many small businesses.

3. The third category is *colleges and universities*. There are two ways in which the small businessman can obtain technical assistance from such institutions. The first involves working with the university as a whole, largely through its research foundation, which serves the purpose of pooling professors and graduate students to do contract research. Many universities provide such an outside R & D service, principally on a large contract scale to government and industry. Among the more notable are Massachusetts Institute of Technology, California Institute of Technology, Johns Hopkins University, and the University of Michigan.

It may be more desirable for the small businessman initially

engaging in outside R & D to make direct contact with individual professors. This is suggested because so many small businessmen regard a few thousand dollars as an excessive annual research expenditure, and because the large university research foundation is not always geared to do small projects. However, most progressive universities permit their faculties to engage individually in outside work for a fee at least a day a week. The small businessman can successfully use this approach, with the cost running from $50 to $200 a day. However, this approach involves certain limitations. The professor cannot work on a crash basis, and it may take him longer to solve a problem than it would one of the commercial laboratories set up to do just this type of work; but on the whole, the use of the right college professor as a consultant for small business is most desirable. The technical contributions he will make will develop a feeling of confidence in science on the part of the small businessman.

4. Technical consultants outside the universities constitute the fourth category, which usually includes individuals or small partnerships, principally in the fields of engineering or chemistry. A small number of these consultants have their own laboratories or staffs, which provide small business with an exceptionally fruitful source of ideas. Again, the local phone book will contain the names of many such technical consultants.

5. The last category comprises the *not-for-profit research institutes* of which there are nine major units: Armour Research Foundation, Chicago; Battelle Memorial Institute, Columbus; Cornell Aeronautical Laboratory, Buffalo; Franklin Research Institute, Philadelphia; Mellon Institute, Pittsburgh; Southern Research Institute, Birmingham; Southwest Research Institute, San Antonio; Stanford Research Institute, Palo Alto; and Midwest Research Institute, Kansas City.

These institutes are somewhat different from either the commercial consulting laboratories or the universities. They are organized on a not-for-profit basis, and are dedicated to serve the public interest as scientific institutes. Most of their work, even though

it may be basic in character, is purposeful and directed toward specific objectives. This serves both the immediate interest of the sponsoring client and, in the long run, the public generally.

While their operating policies with respect to clients are somewhat similar to those of other contract research laboratories, these institutes have an obligation, because of their public status, to cover a broader field. In addition to providing technical assistance to small and large business, these institutes also underwrite considerable research in the public interest and make the results of this research available through seminars, conferences, and publications. These research institutes have raised the level of scientific thinking in their respective localities, and have done much to advance the concept of research and development with the general public and with business people.

Most of these contract research groups have worked out very efficient systems of serving their clients. For example, prior to the initiation of any work, the small businessman can discuss his problems with any of these groups at no cost. The outside research source will undertake a rather thorough study of the problem, prior to preparation of a written proposal which will define the technical issues and set out a detailed plan of attack. The consultant will indicate the results he thinks can be expected and will provide the small businessman with a reasonably accurate estimate of the time and money involved. If the terms of the proposal are agreed upon, the R & D work is carried out in close relationship with the client's representatives. In most instances, frequent project meetings are held, and written reports are submitted regularly. Patent rights to any inventions made are usually assigned to the client. The guidance and control of the R & D work is under close review by the client at all times.

Lest contract research appear to be a panacea, some observations will now be made about problems which have been encountered in this area.

1. The outside research group or consultant is not always familiar in great detail with the client's operation. Attaining the

necessary familiarity may, therefore, require a period of preliminary indoctrination. Some clients have considered the cost of such indoctrination as "tuition" for educating the outside research source. But it is obvious that the sponsoring company or client would have to educate similarly any new people it hired on its own staff.

2. A second objection to contract research is that some outside research groups have implied or stated an ability to accomplish more than was actually possible or have implied the ability to complete an assignment in less time and at less expense than was actually feasible. This does not suggest unethical practices or lack of reputable management, but would indicate a lack of ability to forecast results.

3. When outside groups are employed for R & D, some of the experience and know-how acquired during the research is lost to the client's staff. Some sponsors of outside research consider this to be a very important disadvantage.

4. Many sponsors of outside research, particularly those in the small business category, like to maintain very close contact with the outside technical work. This can easily be overdone, and too intimate and frequent control often stifles the initiative of the outside group.

5. Some businessmen still cling to the idea that their trade secrets are too precious to be trusted to anyone outside their own company. All of the reputable contract research groups and consultants succeed completely in maintaining adequate secrecy. But to the uninitiated client, particularly the small businessman, the question of secrecy looms often as a serious deterrent.

6. Another contention is that the cost of having research done by an outside agency is higher than that incurred when research is done within the organization. Most studies show that the outside agency can carry on the work less expensively than the company can do it itself, but, since accurate cost data on R & D are lacking in many companies, particularly in small businesses, there is a tendency (especially at the time when monthly invoices arrive) to consider contract research the more costly.

7. Finally, there is the problem of internal relations with the client's own technical staff. Some employees will regard the engagement of "outside" research help as a reflection on their own ability to do the work; some regard it as taking funds away from their own efforts.

Generally speaking, despite the disadvantages of contract research discussed above, the advantages are great enough to favor this sort of technical help. Some of these advantages are as follows:

1. Contract research eliminates completely or reduces substantially the need for capital investment or laboratory staff. It costs about $20,000 per research man to build and equip a research laboratory in the field of chemistry, for example (this means the capital expenditure after taxes).

2. The costs of contract research are substantially lower than those of doing the work inside the company. A recent survey showed the cost difference to be about $7,400 per man year. This is not difficult to understand if one takes into account all charges. But many small businessmen fail to visualize all the costs included in the contract "package price" per project and invariably think the outside charges to be excessive. The budget control and evaluation of research progress is much tighter if an outside group is employed.

3. Another great advantage is that the client gets the benefit of a wide variety of skills, even though his project may involve only one man in the contract research group. This man always has access to his skilled associates and to scientific leaders.

4. The cost of scientific equipment is something to be considered carefully. Occasionally, a specialized piece of apparatus may be used on a project only intermittently and it is not economic for the small businessman to purchase it. It is standard practice for the contract research laboratory to own such equipment.

5. Another advantage is that contract research groups or consultants can often suggest marketable applications of new products because of their own extensive backgrounds. They may sup-

ply many ideas in this field which the client himself would not have visualized.

Before engaging an outside contract research group or a consultant, it might pay to ask a few questions, such as the following.

1. What is the pertinent background or experience of the outside agency in your particular problem area? This experience need not be too specific, but it must be in a scientifically related field. The outside agency may be quite capable of solving your problem without having faced precisely the same problem previously.

2. What is the "batting average" of the outside group with past and present clients? Who are they? It may be well to talk with some of them.

3. Does the outside group have access to good scientific literature facilities?

4. How much self-generated research does the outside agency do? This is a measure of its initiative and of the creativity of its staff.

5. In the outside group, who is going to work on your project? Is it the man you have dealt with directly or someone else in the outfit? Matching scientific skills and problems to be solved is the crux of all good research management.

6. What are the contract conditions? Will your project be quoted to you by phases, so that you can evaluate it as time goes along? What are the conditions for terminating the project? How often does the outside group terminate a project of its own volition?

Finally, I would admonish the small businessman to consider the following points.

1. Don't expect research to be a magic key to success. Results cannot be guaranteed on any problem that is worth solving. Be sure you have ascertained the degree of marketing problem you will face before you solve your technical problems outside. Many a brilliant technical idea has terminated in a market fizzle.

2. Work closely with the contract research people you engage. They are ethical and honest.

3. Play square with the outside research group. Don't ask them for a proposal and then sit on it for months. The outside person has put a lot into his initial contacts with you and particularly into preparing this proposal, which, if well done, may represent half the solution to the problem.

4. Once you find a good contract research group, whether a college professor, a consulting laboratory, or a research institute, stay with it. Don't shop around.

5. Don't expect 100% success on each problem the group undertakes for you. No one does that well.

6. Don't wait until you are desperate and in trouble. Make the outside contacts and engage assistance while time permits.

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ORGANIZATION, ASSIGNMENTS, AND EXPECTATIONS*

C. L. FLEMING, JR.
Vice President, Esso Research and Engineering Co., Linden, New Jersey

Since all of my experience has been with research in a relatively large organization, I had some concern about whether this background gave me any right at all to talk about the role of research in businesses more modest in size. After giving this matter considerable thought, however, I have come to feel that the differences between research in large industrial establishments and in those of smaller size are differences of degree and not of kind. To express this another way, I would say that while the size and nature of a company's activities will influence the size of its research establishment, I see no reason why company size should bear any relation to the question of whether or not research is conducted. In fact, as we go through this discussion it may well be that many of you will decide that your companies are already doing research of one type or another, although it may be on an informal or part-time basis.

With this general introduction, let us now turn to a discussion of the question of what industrial research really is, and with what kinds of things an industrial research organization should be concerned. There is, I think, a rather popular view that re-

* Presented at the Industrial Research Institute–Young Presidents' Organization Symposium on Industrial Research, New York, N.Y., March 2–3, 1959.

search laboratories are weird places inhabited by rather peculiar people. The laboratories are considered to be full of all kinds of complicated and expensive equipment which makes strange noises and emits a soft glow of light; the research scientist is pictured as a rather unconventional person who normally wears a white coat, during working hours at least, and speaks a strange language which can be understood only by his fellow workers. The results of the activities of these scientists are then imagined to be very abstract scientific theories far too complicated for ordinary people to understand.

This picture, however glamourous, is far from the truth. It must be admitted that some of the tools used by the modern industrial research man are complicated and, in some cases, expensive. On the other hand, the same thing can be said of the modern accountant with his electronic calculating machines. Often it is not realized that the industrial laboratory leans heavily on common equipment of the industry with which it is associated. Thus in the laboratories of a company in the plastics industry one will see plastics and machines for testing their strength and durability; in a laboratory in the petroleum industry one will find various oil products and equipment in which those products are used, such as ordinary passenger-car engines.

The people in a research laboratory are perfectly rational and normal human beings who live ordinary lives but who preferred to study physics or chemistry or engineering in college rather than economics or sociology or business administration. If they have any particularly distinguishing characteristics, I would say that these are a great curiosity about why things happen and what makes things work, a passion for facts, and a peculiar ability sometimes called creativity. This latter characteristic is, in my own opinion, simply an ability to takes eemingly unrelated facts and make them fit together in such a way that a complete and intelligible picture results.

Having taken away the veil of mystery from the modern industrial research laboratory, we can now turn to a discussion of

how the research group operates. There are, of course, many ways of looking at this matter. One school of thought follows the line that it is necessary to have a research activity in one's own company because all of one's competitors have a research establishment, and therefore, by definition, that research is a good thing to do. Under such conditions of doing research because it is stylish to do so, company top managements are likely to allot a certain amount of money for research and then sit back quietly and wait for good things to come from it. I suspect that some research departments like and encourage such an attitude, since it practically guarantees that the research director can run his organization with a minimum of interference.

As I said, I believe that some industrial research groups operate in this fashion; yet, to me this seems to be a very peculiar way to run one's business. Surely no manufacturing department would carry out its function in such a manner, and even if it wanted to, no company management would permit manufacturing operations to be run this way. It is difficult to conceive of the manufacturing arm of an industrial enterprise setting production schedules and building up an inventory of a product without bothering to find out whether there was a market for the product and whether the sales group was interested in marketing the particular product in question. This, however, is precisely what the research group is doing when it pursues a course leading to something new without finding out ahead of time whether the new thing will be of interest to the company.

You probably have inferred by now that I am not in favor of such haphazard research as the type I was just discussing. This is certainly the case. What I would advocate instead is a research organization very closely geared to the needs of the company, both now and in the future. In this case the research group can fulfill its true obligation to its company—to make certain that the company has the technology it needs to carry out its present operations and those it plans for the future in the most economical and most efficient way.

This means that the research group should be concerned with all phases of the company's activities from raw material to finished product. Research, for example, should be familiar with the raw materials used in the company's operations. It should know where they come from, how they are made, and how much they cost. Furthermore, research should know precisely what properties and characteristics are required in these raw materials for optimum performance in the company's operations. With this knowledge, the research group would then be expected to keep up a continuing program aimed at reducing raw-material cost. As you know, such economies can be effected in a number of ways. Sometimes lower-quality raw materials can be substituted for more expensive, higher-quality starting materials without affecting the quality or performance of the final product in the least. New materials are being introduced constantly, and the research group should keep constantly aware of these, with the thought that perhaps a new and cheaper raw material can be used. Finally, the research organization should know enough about the industry which produces the raw materials so that it can make suggestions to its raw-material suppliers about possible changes or substitutions which will lead to economies. What I am trying to say here is that the research group should take positive and aggressive action with respect to raw-material costs, and not merely have a passive attitude of waiting for new things to come to it.

There is one additional point I should like to make in connection with the research group's responsibilities on raw materials. This point is quite obvious, and yet it is frequently overlooked. It is merely that the research organization needs to keep familiar with the company's overall plans in order to avoid the unfortunate situation of spending research money on raw materials for a product which the company plans to discontinue. This is of course sheer economic waste; but it illustrates one of the main points I want to bring out, namely, that the research group needs to be sure of the value and usefulness of its potential result before it starts the work aimed at giving that result.

The situation with regard to manufacturing operations is quite similar to that relating to raw materials. Here again, research needs to be familiar with all phases of the manufacturing process. This should include detailed information on all of the process steps—purpose, yield, number of rejects, cost, quality, quality standards, etc. With this background, the research group would then be expected to make recommendations aimed at either reducing manufacturing cost or reducing capital investment for new facilities if it is decided to increase output. The research organization ought to be expected to have at least some knowledge about how competitors carry out the same transformation from raw material to finished product, and to be reasonably familiar with competitive developments. In industries where the final product is the result of a number of discrete steps (such as in the manufacture of pharmaceuticals), and manufacturing cost is primarily influenced by the yield in each step, research obviously would be concentrated on improving yields. Similarly, in industries where manufacturing cost is heavily influenced by capital investment, research ought to be expected to devote primary attention to ways of doing the job with lower equipment cost.

Here again it is abundantly clear but nevertheless frequently overlooked, that research needs to know overall company plans. If the research function does not have this information, it may find itself in the unhappy position of spending money to improve a process for making a product which company management intends to discontinue.

Similar problems, objectives, and expectations exist in the field of research on products. Here the research arm of the company should have a clear picture of what the product is supposed to do, how well it does this, what customers expect, what influences product performance, how well competitors' products perform, and when new or improved products are needed. This means quite simply that research needs close liaison with the sales group and must have a clear understanding of the end use to which the product is put.

So far we have dealt primarily with research's relationship to a company's going business. This, however, is only part of the story. In addition to providing the technology required to support a company's existing position, research should be expected to provide technical support for future operations. Let's look at some of the points to be kept in mind in this area.

First of all it should be stated that, if a research group is going to provide the technology that a company will need in the future, the research people must have a clear picture of the course company management has plotted. This in simple terms means that research must understand whether the company intends to remain in one line of business or to diversify. If company management is thinking of diversification, research needs to know the directions being considered. Research needs to know also something about the future availability of capital for investment in new facilities, for this can have a great influence on the types of new activities which reasonably can be considered. Finally, research needs to have intimate knowledge of the skills and abilities of the manufacturing and sales arms of the company in order that the research group can give an intelligent opinion as to whether or not a proposed new line of endeavor is within the technical capabilities of the company as a whole.

If research is to meet in full its obligations to the company, then it should be a full partner with the manufacturing, marketing, and financial arms of the company in helping to pinpoint the company's future. With such an understanding of the enterprise's abilities and capacities, the research group can intelligently undertake studies which will lead to new lines of business. In this way, research can avoid work leading to new processes or products which are completely incompatible with the company management's overall philosophy, or leading to processes or products which are completely impractical from a capital-investment point of view. This brings me back once more to the main thesis of this discussion—that if industrial research is to be successful and is to discharge its true obligation, it must ascertain ahead of time that

the result of a research program will really be useful to the company.

Assuming that the conditions we have just been discussing about the future activities of the company have been met, the research department has one further job to do. This is deciding how much effort to put on problems relating to the company's present business and how much on problems of the future. A decision here that errs in either direction can lead to difficulties. There is obviously little to recommend a course aimed so thoroughly at solving today's problems that by the time they are solved the company is hopelessly behind technologically. On the other hand, there is no more to recommend a course aimed so thoroughly at solving tomorrow's problems that by the time tomorrow comes the company is out of business. Either course can easily lead to the unhappy position of having at once achieved a scientific triumph and a practical disaster.

The solution to this dilemma lies in the research director himself. Through his own knowledge and skill, supplemented by information flowing to him about the financial, manufacturing, and marketing abilities of his company and about similar capabilities of his competitors, he must decide how to split his forces. This I think is true regardless of the size of his organization—whether it be one man or a thousand.

In many ways the success of an industrial research organization depends on its leader. It is clear that he must first of all have some type of technical background. This he needs if he is to be able to guide work intended to lead to new scientific advances. He also needs this background in order to appreciate the possible impact of such advances on his company's business and integrate them with his company's aims and capabilities.

This, however, is not enough. The research director must also be salesman enough to have an appreciation of marketing problems. Customers do have problems, and he should expect to be called on for suggestions and advice. He must realize that such situations need to be taken seriously and that it is not at all degrad-

ing for a research organization to do technical work aimed at solving the sales department's problems. It is not unheard of for sales people to urge the research group to make changes in a product when troubles arise. The research director needs to have the courage to defend the product if in fact it has been misused. But he also needs to have the vision to see product deficiencies when they exist and take the necessary corrective action.

Beyond this, a leader of research should have enough of a practical outlook to understand and be sympathetic to the company's production problems. If this understanding does not exist, there is always the danger of the research group coming up with new products or new ways of making old ones which are completely beyond the company's manufacturing capabilities. In addition to this aspect of the problem, troubles can develop in the manufacture of established products, and the research department ought to be willing and able to help in their solution.

Finally, I want to mention the qualities of organizational ability and leadership. These apply of course more to the relationships of the research director with his own group than to his relationships with the rest of the company's operations. If a research group is to consist of only two or three people, I would agree that organizational ability is not very important. But if the group is to be of any significant size at all, the research director must organize the work so that everyone is clear as to exactly what is expected of him. As in any other type of work, clear lines of responsibility and communication must be established. In short, the organization must be so set up that it will operate with maximum effectiveness and efficiency.

But leadership is probably the most vital characteristic of all. It is essential regardless of the size of the research group. The need for leadership in research is in many ways no different from the same need in other activities. There is, however, one major difference between research and other industrial functions. This is in the output of the function. In the case of research, this output is ideas created by people. Ideas cannot be bought before any-

one has them, nor can they be produced on order. The research director's prime job then is to so motivate people that they produce good ideas on subjects of interest to the company. This he must do by instilling a feeling of self-confidence in his group, by working with and intellectually stimulating his people, and by his own example. In this way he can discharge his primary responsibility, which is to create an atmosphere conducive to the generation of ideas.

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REPRESENTATIVE COSTS OF DOING RESEARCH AND DEVELOPMENT*

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I. Trend in U.S. Research Spending

Before discussing specific costs of doing research at the present time, it will be helpful to note how much money is being spent for research and how rapidly research has grown during the past half-century.

Since 1920, the rate of research spending in the United States, including that of the government, industry, and universities and institutions, has increased 100 times until it is now at an annual rate of over $10 billion. During the past forty years, research and development spending has, on the average, tripled every ten years.

Research spending, as a percentage of the gross national product, has averaged 2 to 2.5% during the past several years. If the present exponential growth of research continues during the next twenty years, research spending will reach an annual rate of $18 billion by 1970 and $25 billion by 1980. Figure 1 shows this trend.

During the 1960's the estimated $150 billion to be spent on research will amount to nearly twice the nation's total investment in science and technology in the 183 years from 1776 to the present.

* Presented at the Industrial Research Institute–Young Presidents' Organization Symposium on Industrial Research, New York, N.Y., March 2–3, 1959.

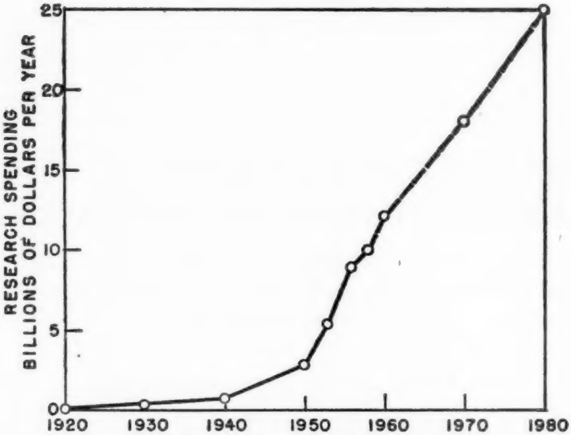

Fig. 1. Research spending in the United States.

The present level of $10 billion per year puts research in the category of big business. By comparison, the 1957 sales of the country's largest corporation, General Motors, were $11 billion.

II. Typical Cost of Operating Research and Development Laboratories

1. *Running Expenses*

Running expenses vary according to the type of industry. Typical R & D costs for chemical, petroleum, steel, aluminum, and coal laboratories are currently about $11,000 per year per R & D employee. Salaries and benefits account for 65 to 75% of total running costs. Figure 2 shows current data and the increase since 1950.

Running expenses per professional employee are currently about $25,000 per year. This figure also varies according to the

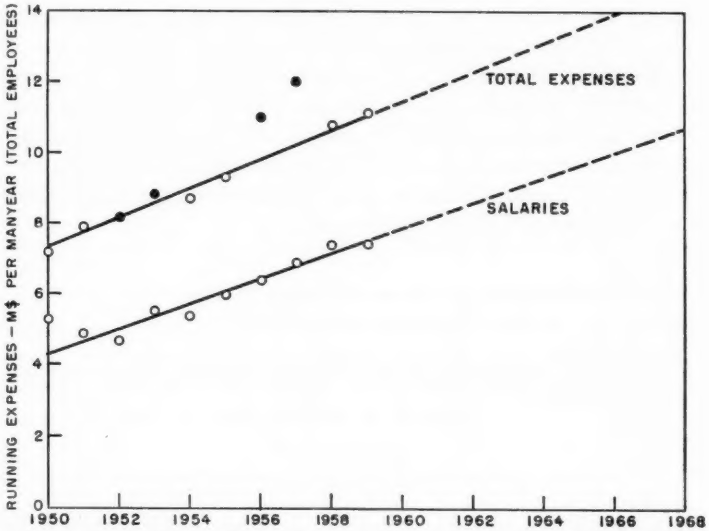

Fig. 2. Research and development running expenses: Thousands of dollars per year per man, all employees. (●) Pilot plants in operation. (○) No pilot plant operations.

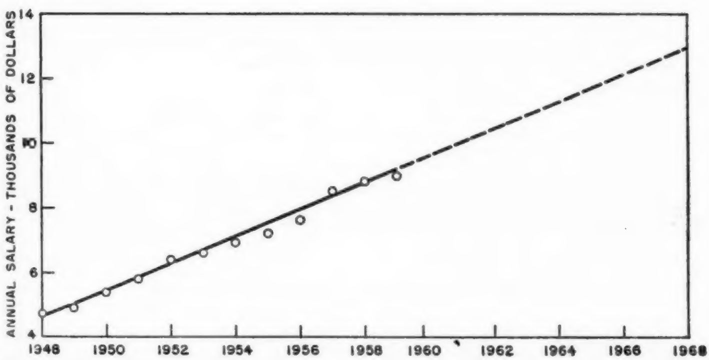

Fig. 3. Trend in average salary rates for professional employees in typical research and development organizations.

industry and will also increase or decrease depending upon whether major pilot plants are being operated or not.

Running expenses have increased over 50% since 1950, and this trend is expected to continue. During this same period, salaries increased over 60%. Figure 3 shows the trend in average professional salary rates in a typical research and development organization. Similar increases have occurred in the salary rates of technicians and clerical employees.

2. Typical Breakdown of Expenses in a Research and Development Organization

A typical breakdown of the running expenses of a laboratory is given in Table I.

TABLE I

Item	Expense, % of total	Cost, $/ employee/ year
Salaries and benefits	75	$8,200
Materials, supplies, minor equipment, utilities, travel	16	1,700
Management charges, professional services, hired services, recruiting	7	800
Insurance, taxes, depreciation, rental, memberships, advertising	2	300
Total	100	11,000

A typical breakdown of extraordinary expenses in a research and development organization is given in Table II.

3. Capital vs. Expense Outlays for Research

Comparison of average costs of doing research can be misleading. Some R & D organizations charge off all costs to expense except such things as automobiles, office and laboratory buildings,

TABLE II

Item	Expense, % of total (extraordinary)	Cost, $/employee/ year
Major supplies, equipment, furniture and fixtures	60	420
Fellowships	13	90
Outside contracts	27	190
Total	100	700

and certain higher-cost items of equipment. This tends to give higher running expenses than the average. Other companies capitalize all equipment regardless of costs, and capitalize all buildings, including pilot plants. As a result, these organizations show lower running expenses than the average.

III. The Cost of Research Laboratories

The costs incurred in constructing in suburban Pittsburgh a laboratory building including office space and laboratory equipment, benches, hoods, sinks, etc. are summarized in Table III.

TABLE III

	Area	No. of persons	Area/ person, $ft.^2$	Total cost, $	Cost/ $ft.^2$, $	Cost/ person, $
Land	30 acres			100,000	2.60	
Building	38,000 $ft.^2$	80–100	380–475	900,000	23.60	
Total				1,000,000	26.20	10,000–12,500
Annual operation				80,000–100,000		10,000

As an example, cost data are given for construction and equipment of a relatively small organic research laboratory which accommodates 10 employees (Table IV).

TABLE IV

	Dimensions, ft.			Area, ft.^{2}	No. of persons	Area/person, ft.^{2}	Total cost, $	Cost/ft.^{2}, $
	H	L	W					
Building	20	20	33	1400	10	140	40,000	
Equipment							14,000	
Total							54,000	39

Cost data for a somewhat larger building used for coke test work are shown in Table V.

TABLE V

	Dimensions, ft			Area, ft.^{2}	No. of persons	Area/person, ft.^{2}	Total cost, $	Cost/ft.^{2}, $
	H	L	W					
Building	26	48	33	2310	6	385	62,000	
Equipment							16,000	
Total							78,000	34

Average costs of building and equipping a laboratory in various parts of the U.S. are given in Table VI. Here, building costs refer to cost of construction; equipment costs include the cost of laboratory occupancy: benches, hoods, sinks, etc.

TABLE VI

	Cost/ft.^{2}, $
Building	23–28
Equipment	4–7
Total	27–35

Figure 4 compares the cost of laboratory construction in four sections of the U.S.

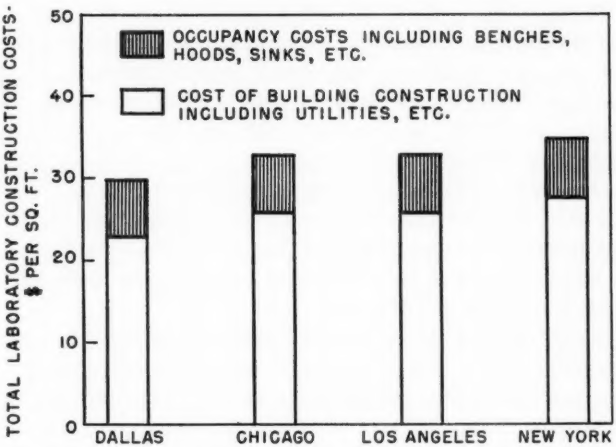

Fig. 4. Laboratory construction costs, 1957. Dollars per square foot. (From *Chemical Week*, December 7, 1957).

IV. Budgeting for Research

Budgeting research expenses is necessary in order to control costs and determine the direction of the research program. Research budgets are similar to other types of plant operating budgets.

Control of manpower is the most important phase of research budgeting. By controlling the number of R & D employees, all research and development costs are controlled.

Research and development work should be divided into individual projects, which may then be regrouped into main research categories.

In preparing a budget, a research program is first prepared by projects. Manpower is then allocated to the various projects and average salary rates are used to calculate the total salary budget. Other running costs are determined on the basis of type of project; i.e., process design, laboratory, pilot plant, etc.

Extraordinary costs, including construction of pilot plants, major equipment, outside consulting, and other items of major cost which are not considered to be normal running expenses, are itemized, insofar as they are known, and are added to the specific projects. Extraordinary expenses will vary between several hundred and several thousand dollars per employee per year depending upon whether pilot plants are being constructed or not.

The sum of the direct expenses of the above types becomes the initial budget; it is prepared on an annual and quarterly basis. It is not necessary to be too precise in preparing these budgets. Slide-rule accuracy is sufficient.

A typical research and development laboratory with an annual budget of several million dollars may have 30 to 40 active projects at any one time. Smaller laboratories may have only several active projects.

V. Accounting for Research Spending

All costs which are incurred specifically and entirely for a project or projects should be charged directly to such projects, and only those expenses which are purely general in nature should be charged into the overhead expense accounts.

Labor costs and the cost of all materials, supplies, equipment, and all other items used on the project are charged directly.

Overhead charges are allocated to projects in many different ways. One of the simplest methods is to distribute them on a direct-labor dollar ratio basis. Some overhead charges, such as building and facilities expenses, can be allocated on the basis of floor space.

Many laboratories do not provide for overhead costs in the budget appropriations made to the various research projects. Although the monthly financial statements for each project usually have overhead costs allocated to give gross project costs, the research supervisors are held accountable for the direct project costs only.

VI. Controlling Research Spending

In order to control research spending, all costs are identified by a project number and monthly and year-to-date financial statements are prepared for each project. Comparisons are made between the budget and actual expenses, and any major differences are discussed with the supervisors and changes in the program are made if necessary. Speed is essential in order to get the financial statements into the hands of the supervisors as soon as possible after the expenses have been incurred. The individual project statements should be ready by the tenth of the following month in order to be useful. Normal business practices are followed, whether the costs are for manufacturing or for research.

Simple project statements which show the principal items of expense are sufficient to allow research spending to be controlled very effectively and with a minimum of clerical help. For small research organizations of up to several hundred employees, punched-card accounting systems with searching by means of a hand needle are not only inexpensive to operate but very fast, efficient, and completely satisfactory. Adding-machine tapes are used as a record of expenses and no other accounting ledgers are required.

In larger research organizations of over 500 employees, machine accounting is usually quicker and more satisfactory than hand-punched cards.

VII. Cost of Various Services for Research and Development Organizations

A research and development organization with 150 to 200 employees and an annual budget of about $2 million can handle all of its purchasing, accounting, budgeting, and payroll requirements with five employees at an annual cost of $33,000. This is 1.65% of the annual research budget. Many research organizations have found that having their own service groups within the research organization offers many advantages at relatively small expense.

Other companies have found it equally satisfactory to centralize their business functions and have a central purchasing and accounting group for research as well as for manufacturing.

One other group which is important to the success of any research organization is the information section. This includes the technical library and central files. The only product of a research organization is information in the form of memos, formal reports, and other written material. These should be filed properly and in such a manner as to be readily available to the researchers and research management.

Most research laboratories require the services of a machine shop assigned as an integral part of the research organization. R & D shop employees are skilled in construction and maintenance, and in the repair of technical and scientific equipment. As a rule, production shops are not geared to R & D needs, hence the necessity for having a machine-shop force as a distinct part of the R & D organization.

VIII. Is There a Minimum-Size Research Organization?

A survey was made recently of the more than 100 research laboratories in the Pittsburgh area. This study, which was made by the Regional Industrial Development Corporation, shows that half of these research laboratories have fewer than 20 research workers each. One-fourth of the laboratories have fewer than 10 employees.

One must conclude that there is no minimum-size research organization. Costs of these smaller research organizations follow the same general pattern as the average laboratory which is many times larger. This is shown in Table VII.

As you can see, research is costly and will probably become even more expensive in the future. I know of no alternative to research, however. Industries and companies which do not spend research dollars can look forward to a limited life. Research will

TABLE VII
Comparison Between Small and Average-Size Research Organizations: Pittsburgh, Pa., Area

	Small	Average
Number of laboratories	90	115
Average number of research employees	18	150
Average investment/employee	$ 12,900	$ 13,200
Average laboratory space	30,000 ft.²	115,000 ft.²
Average acreage	—	48 acres
Average annual budget	$166,000	$1,380,000
Average annual cost/employee	$ 9,200	$ 9,200
Average annual cost/scientist	$ 31,000	$ 20,000

not necessarily guarantee them longevity, but it will at least give them a fighting chance.

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USING JOB DESCRIPTIONS IN RESEARCH LABORATORIES*

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One of the most significant features of the development of modern management techniques has been the recognition of the common administrative philosophy underlying all organized activity. It has become clear that, whether one speaks of a retail business, a petroleum refinery, an airline, or a research laboratory, there is an approach to the management of the enterprise which has the same basic elements. These elements have been variously labeled by writers in this field, but they are recognizable by the designations:

Planning
Organizing
Directing
Coordinating
Controlling

In planning, we visualize the goals and objectives of our enterprise and the facilities needed to achieve them, and we establish policies that formalize our purposes. We then organize the ac-

* Presented at an Industrial Research Institute Study Group on the subject, "Job Status as an Award for Scientific and Administrative Accomplishment," New York, N.Y., February 26–27, 1959.

tivity into groupings that are logical entities and are balanced in importance and size. Out of necessity and convenience and to take advantage of specialized talents, we delegate authority to act consonantly with our established policies. This step is part of the obligation to direct the enterprise toward the goals we have established. It then becomes our responsibility to insure that the various activities work together as a functioning unity and that our relationships and approaches are harmonious and synchronized. Finally, there must be a measurement of performance against a standard to provide an objective basis for corrective action.

Job Descriptions in Organizational Planning

Let's look at where job descriptions fit into this picture. Writing a description of a position is a key step in the orderly implementation of the organization plan which requires an analysis of the relationships of this job to other jobs and functions. Th re must be detailed consideration of the responsibilities to be discharged and an assignment of authority commensurate with this responsibility. Finally, standards of performance should be defined and lines of accountability indicated.

A more detailed examination of what a job description should include will make this clear.

1. A job description should define the scope of the job and thereby formulate goals.
2. A job description should provide a basis for objective performance appraisal.
3. A job description should define relationships; many different kinds of relationships may be described. Some typical ones include reports to, supervises, complies, advises, coordinates, serves, inspects, audits, appraises, evaluates, and cooperates.
4. A job description should fix responsibility.

5. A job description should delegate authority—and this must be commensurate with the responsibility.
6. A job description should provide a basis for rational salary administration.
7. A job description should assist in the selection of meaningful job titles.
8. A job description should constitute an aid in recruiting by providing an objective basis for selection.
9. A job description should provide a basis for comparing rate structures and relationships.

Job Descriptions in Salary Administration

There is a widely held impression that the sole purpose of job descriptions is to set pay levels. As a consequence of this interpretation, it is felt that, by using job descriptions, you fail to distinguish between the man and the job.

An important point is to recognize that job descriptions are not exclusively tools for salary administration. They are only incidentally useful for that purpose, but primarily are broadly applicable in organizational planning and control as indicated in the foregoing outline.

In well-conceived salary-administration programs, virtually all jobs have associated with them a rate range which is designed to cover performance from the least satisfactory level for continued employment to the optimum desired. The distinction between the man and the job is made by paying him appropriately for his performance within the rate range.

If it were possible to use other guides in setting salaries, say age or perhaps some other measure not connected with job content, the value of job descriptions in an organizational activity would remain undiminished. Let us now leave the discussion of the salary-administration aspect and focus our attention on the other phases of job descriptions.

Using Job Descriptions

Consider a general case: a need emerges for a new job. The job arises out of an organizational need; that is, in order to implement certain company plans, a particular function must be performed. A job description or specification is then written to describe the performance requisites for implementing the company plan. The job description will, of course, cover the details of responsibility, authority, relationships, standards, etc., in terms appropriate to the position. A search is then made for a man with the proper qualifications and interests to fill the job.

We must now ask if there is anything unique about the organization or operation of a research laboratory that would make this approach not applicable. I think the answer is clearly *no*. When a new job opens up in a research laboratory, it comes into being because management has agreed to a plan which will probably manifest itself in a research project. The nature of the project in this case determines the content of the job description as well as the specific terms of reference used in writing it up.

Let us now consider another general case. A man is performing a job and we want to write a job description for him. We examine what he does, to whom he reports, what his organizational relationships are, what standards of performance exist, etc., and we compose these into a job description. We then see how the job as performed matches the organizational plan it is designed to fulfill.

Again we must ask, is there anything unique about a research laboratory that makes such an approach not feasible? I think again it is clear that there is no conflict between this general case and the research-laboratory situation. Here we look at the research worker at his job and see how he gets his work done, what pattern of relationships he has found it necessary or convenient to establish, where he gets his direction and supervision, etc. When this man was hired or when his present project was started, certain expectations existed about these factors. His job description de-

rived in the manner indicated can tell us if our initial expectations require modification or alternatively, if he should change certain of the things he does.

Applying Job Descriptions in Research Laboratories

Well then, do we have a problem? Yes, clearly we do, as is seen in specific cases for which we must try to write job descriptions. The problem lies in attitudes regarding professional jobs and scientific jobs in particular. There are five very characteristic arguments that one hears offered in opposition to writing job descriptions for research-laboratory personnel.

1. You just can't describe such jobs.
2. If you do describe them, you can only use generalities which have no meaning when you are done.
3. You introduce a rigid structure into what must be a flexible organization.
4. You impose *a priori* limits to advancement.
5. You introduce status problems.

These are certainly serious objections whose validity we are under obligation to explore. To be sure, the jobs of professional persons and research scientists are not routine and are therefore not subject to the specialized job-evaluation techniques used by industrial engineers and time-study men in rating hourly jobs, but does this mean we are unable to say anything meaningful about them? Such a conclusion is clearly inadmissible, for if we accept it we must confess that our ideas on fulfilling the organizational plans for which the position under discussion was created are equally vague. This situation is somewhat embarrassing, because it is often true that our organizational plans are so vaguely drawn or our ideas about how to fulfill them are so poorly formulated that it is very difficult to describe the job in meaningful terms. While we may be a long way from being able to use quantitative

measures of performance for professional jobs, as scientists, we should still insist on using the most systematic approach available.

Some fundamental attitudes about research also affect the approach to the use of job descriptions. Research in the industrial environment is an entrepreneurial tool of management. It has a specific job to do for the enterprise and therefore the job is fairly well defined in most cases. There are certain fields of science and technology in which the sponsoring company must maintain or extend its position. There are, more specifically, certain products or processes that must be protected, and these delineate further the needs for the research. Some of our very largest corporations whose interest spectrum is very broad permit a great deal of freedom on the part of some selected, high-caliber scientists in the choice of the area of their work, but in most cases there is a fairly definite place in the rationale of the laboratory and its program for the functions performed by the staff members. This has become increasingly the case as the complexity of modern research has required the team approach in the pursuance of modern research programs.

Some research managers will offer as a formula for performing successful research the following three steps: (*1*) hire a good man; (*2*) give him the facilities he needs; (*3*) leave him alone. I think that this formula has achieved some degree of acceptance in the research community due to inexperience in group effort or to the reaction, in my opinion a justified one, against unenlightened and overly enthusiastic attempts at control of research by those who don't understand it. There is an obvious fallacy in the formula, however, which is disclosed by the question, "What, then, is the function of research management?" If it is merely to administer the researcher's environment, then surely we have a lot of overpaid persons in research management today.

We must, I think, admit that research managers must be deeply committed in the overall planning, organizing, coordinating, and controlling of the research for which they are responsible. The job description, to the extent that it fulfills the requirements

listed earlier, is a measure of how well the research operation is planned, organized, coordinated, and controlled.

Misunderstandings about the function of job descriptions are responsible for other charges that are leveled against them. To say that job descriptions introduce a rigid structure into an organization is an example of this kind of misunderstanding. The job description describes the existing structure. Structure derives from the planning and organizing that has gone before. The job description reflects what is in existence and what is intended. If you wish to employ a top-flight scientist and "give him his head," then it seems to me perfectly proper to write a job description that provides for just that.

Similarly, to say that job descriptions impose limits to advancement is another manifestation of misunderstanding about their true function. Advancement should take place as a result of factors such as improved competence of the individual, new organizational opportunities, etc., and the job description merely follows along to formalize and define the new set of relationships, responsibilities, etc., that result from the advancement.

Finally, it is said that status problems are introduced when you employ a system of job descriptions. But status *per se* should not constitute a problem. Rather, it should be regarded for what it is—a powerful incentive. It has been so used for all of the recorded history of mankind's organized activity.

Problems arise when inordinate emphasis is placed on status as a goal at the expense of the legitimate goals of the enterprise. When this occurs, something basic in the organization is at fault; there may be poor morale, insecurity, lack of leadership, and so forth. Under these circumstances, the scapegoat may well become the job-description system.

Some "Don'ts" in the Use of Job Descriptions

With the increasing emphasis on the team approach, the management of research is becoming an even more challenging

task than in the past. Job descriptions are not the panacea for all of the problems of the research manager, but they can make a useful contribution as we have shown. It will perhaps be useful to state some "don'ts" in administering a job description program.

1. Don't write job descriptions and then ignore them. Job descriptions must be kept up to date and must reflect the current plans and organizational intent of the activity as well as the changes introduced by the functioning incumbent.

2. Don't hide the job description from the incumbent. Normally, the man in the position should write the job description and have it reviewed, corrected, and approved by his supervisor. This action actually helps build an understanding between the supervisor and the subordinate.

3. Don't appraise the performance of the incumbent without reference to the job description; the job description should provide the standards against which performance is measured.

PROFESSIONAL AND ADMINISTRATIVE LADDERS: THE ADVANTAGES OF BROAD JOB CLASSIFICATION IN A RESEARCH ORGANIZATION*

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The term "professional ladders" for nonsupervisory engineers and scientists implies a climbing contest unbecoming the efforts of such respected members of our society. The current popularity of these ladders is reminiscent of certain styles which, once established, are difficult to discard.

Two reasons are commonly put forth for the establishment of these ladders that are parallel in respect to salaries with "administrative ladders," namely, (*1*) they provide a status symbol for outstanding persons, and (*2*) they serve as a convenient mechanism for rewarding such people financially. That these purposes can be achieved without "ladders" has been adequately demonstrated. It is the objective of these remarks to show that a broad system of classifying people engaged in creative engineering and science has many advantages over a system which divides such people into a series of named vertical merit or performance cells.

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It should be made clear at the outset that scientific accomplishment should be rewarded on a basis equitable with respect to rewards for administrative accomplishment. Also, distinguished scientists and engineers should be given the status to which their achievements properly entitle them. It is not necessary, however, to label one group junior, another associate, another senior, etc., in order to designate the current level of their accomplishment.

Outstanding creative scientists or creative engineers can and should receive incomes comparable to those received by persons in administrative positions. The salary ranges for the non-administrative and administrative personnel should overlap. The extent of this overlap should be related to the value of the individual contribution. Dr. C. G. Suits, Vice President and Director of Research at General Electric, recently stated, "No good substitute has been or is likely to be discovered for salary or direct compensation. . . a sound compensation plan, together with an equitable and practical method for its administration, should be the starting point in any consideration of recognition for technical people." Few would argue or even assert that a vertical ladder classification system for technical professional people is essential to achieving this overlap of financial rewards. No one would assert that such a system should replace salary recognition.

Classification names do not mean the same thing to different people. Along with the problems of semantics, there is much confused and fuzzy thinking about classification of scientists and engineers in research and development. There is a tendency to make classification and the recognition of these people more complex than it really is.

Some of the basic ways in which professional technical people may be classified are:

1. Organizational level (president, vice president, etc.)
2. Function or type of work (research, development, etc.)
3. Graded position level (job classification)
4. Level of achievement (merit or performance classification)

5. Profession, skill, or occupation (occupational classification)
6. Level of education, experience, etc.
7. Personal characteristic (physical, mental, age, marital status, etc.)
8. Combinations of *1* to *7*

Although position in any of these classifications may be taken as a status symbol by the people involved, the classifications most commonly used have been adopted for quite different and more important reasons.

Table I shows some typical classifications by organizational level for technical supervision.

These organizational classifications and/or titles are necessary in some form for administrative purposes. Often they are combined with a functional classification, such as Vice President, Research; Vice President, Systems Development; Superintendent, Development Shop; etc. Often organizational classifications are combined with functional titles, such as Department Head, General Commercial Manager; Division Head, Apparatus Engineer; Director, Research; Sub-Department Head, Military Development Engineer; etc. These are all useful names which have meaning to the people in a particular organization. Because they describe levels of authority and/or type of work, they are useful tools in general administration. These names or titles are badges of authority or of function and should not be confused with occupational classifications which indicate an individual's profession, craft, trade, or vocation, i.e., lawyer, doctor, teacher, electrician, engineer, scientist, etc., nor should they be confused with merit or performance classifications such as those proposed for "parallel ladder" systems.

Every complex operation, and R & D laboratories are generally in this category, requires some organization of assignments. Personnel is placed where needed and where most effective. It is good personnel practice to match occupations of individuals to the

TABLE I

General Comparison of Organizational Titles for Technical Supervision

Vice President	General Department Head	Department Head	Subdepartment Head	Supervisor
Vice President	Chief Engineer	Department Head	Section Head	Group Supervisor
General Manager	Manager of Laboratory	Manager (of major division of laboratory)	Manager (functional, of part of Major Division)	
	Department Manager	Section Manager		
Director of Research	Laboratory Manager	Area Manager	Department Manager	Project Engineer
Vice President	Coordinator Deputy Coordinator	Director or Manager Associate Director or Manager	Assistant Director Section Head	
Vice President	Director	Associate Director	Group Leader	
Division Chief Engineer	Chief Department Engineer	Section Manager	Group Manager	
Vice President	Laboratory Director	Associate Laboratory Director	Executive Engineer	Senior Project Engineer Project Engineer
Vice President	Director	Department Head	Section Head	Group Leader
Vice President	Director	Superintendent	Assistant Superintendent	Department Head Section Head
Chief Engineer	Assistant Chief Engineer	Divisision Supervisor	Supervisor Engineering Section	Supervisor Engineering Group
Vice President	Assistant Vice President	Department Head	Section Head	District Head

jobs they are called upon to perform. For research and development workers, it is essential to have a system of job descriptions which is flexible enough to encompass anything that a professional creative individual may normally be expected to do. It is one thing, however, to describe and even name each job, and quite another to place these jobs into labor grades (job levels, ladders, call them what you will). Merit or performance classifications clearly are not job classifications.

Job descriptions, in their proper place, can serve very useful purposes. C. L. Bennett lists the following uses of such descriptions.

External compensation comparisons
Internal compensation comparisons
Performance appraisals
Management development
Recruiting, hiring, and placement
Orienting new executives
Promotions
Self-understanding
Organization classification
Organization planning

Nowhere in this list or in any other list known to the writer is job status mentioned as a reason for having job descriptions.

An important point about professional research and development work is that job descriptions in this area can be precise only as their application is limited on the time scale. The description of the job of an engineer of scientist must be broad if it is to encompass all that he is expected to do even in a reasonably short period of time. Thus, in Bell Laboratories all such personnel is classified Member of Technical Staff, which is a broad general classification of the occupational type. It is believed that the values of individual contributions within this broad classification constitute a continuum and any subclassification, on any basis, would be an attempt to quantize a continuous medium. This statement applies

not only to job or occupational subclassifications but also to merit subclassifications. In the parallel ladder of vertical classifications, however, a series of subclassifications based on contribution, progress, and value, in other words, a system of classifications based on merit, is proposed.

The tendency here is to confuse job measurement with performance measurement. It should be emphasized that the job description is independent of the person performing the job. Therefore, classifications based on job descriptions should not be looked upon as rewards for scientific achievement. How well the individual performs the job as described is merit rating. What we are discussing here is a classification of individuals based on merit and designated by titles. The question is whether there is a real need for a system of separate and distinct classifications and subclassifications of merit in order to recognize nonadministrative scientific accomplishment. Such classifications may be looked upon as barriers to progress for those who do not attain the status of the higher classifications. In academic circles there is a system of status levels based primarily on years of experience: Laboratory Assistant, Instructor, Assistant Professor, Associate Professor, Full Professor. This system is based primarily on length of (teaching) service, with merit consideration added in some institutions and in the higher levels. This is a status award system by which almost every really capable teacher reaches the Professor level at some time during his teaching career. This is not, however, analogous to the parallel ladder system, in which only the "outstanding" scientists (in whatever manner determined) can reach the top classification.

Another approach to this subject would be to start with some obvious premises on which there is general agreement, and then proceed to some less obvious observations on which interpretations may differ.

Recognition and reward for scientific and for administrative accomplishment are desirable in any research and development organization. This implies some form of performance evaluation.

Some scientists, equally capable of scientific achievement, are

better administrators of technical or business matters than are others.

Individual technical contributions in the form of new scientific knowledge, inventions, new applications of old knowledge, etc., may be of equal or greater value to a research and development organization than are the contributions of an administrator. It follows, then, that there should be adequate recognition of this value, whatever the individual assignment.

From this point there will be varying degrees of agreement and disagreement, depending on the ability of the writer to say precisely what is meant, the logic of these remarks, and the reader's experience.

Assignment of administrative duties to a scientist does not necessarily decrease his technical contributions; in certain instances, it may actually increase them. A research scientist or professor with several other scientists, technical aides, or graduate students working with him is usually more productive than one who has no group to supervise. The time required to merit-rate subordinates, sign time cards, etc., is a small price for the advantage of having several assistants who will test and carry out creative ideas. Admittedly, some individuals are most productive as lone workers and are not able to use subordinates effectively. If such an individual is as productive without aides as another is with them, then clearly that individual's higher worth should be recognized and rewarded. One way would be to classify him as a Senior Scientist or Associate Scientist, or continue to classify him, along with the president of the company, as a Member of Technical Staff, as Bell Telephone Laboratories prefers to do. He may, however, be rewarded with an increase in salary, a private office, special furniture or freedoms, or in other ways which reflect this status. Whatever is done, "don't fence him in" in such a manner as to suggest a limit on his contributions.

It is the major premise of this paper that a creative research worker should not be bound by classification or title to any preconceived limit of achievement. He should be working in a

progressive environment unbroken by arbitrary barriers which have to be overcome before producing in a higher environment or "level." Not only is such merit classification likely to introduce psychological fences where there should be none, but also the cost of such a system in administrative effort and confusion far outweigh any benefits the system may bring in incentives.

In saying all this the writer is not unmindful of the value of incentives. However, creative people, such as those under consideration, have other incentives for achievement far more important than attainment of a Senior Scientist or Associate Scientist classification. A scientist is a scientist first and an employee of a company second. He seeks the satisfaction of creative work and of a job well done, he works for status in the eyes of other scientists first and status in the eyes of the officers of his company second. Anything that gets in the way of adequate recognition by his fellow professionals causes frustrations and may seriously affect his productivity. Human nature being what it is, each creative worker strives for maximum recognition, first by his peers; he often feels that he is better than he may actually be, or at least better than his peers or his superiors think he is. He is often critical of others' appraisals of him, particularly his superior's appraisal. Some become frustrated and morose when they are not selected for promotion to administrative positions. An even greater similar effect would be observed if these scientists were not selected for promotion to higher nonadministrative positions. Instead of a parallel ladder, there would be established a parallel race track. It would be well to remember that, every race usually has *one* winner, often *several* losers.

If another set of nonadministrative levels for research personnel is established, those who attain the higher levels may be pleased, but others are going to be made uncomfortable because they are not chosen for promotion. Another step, indeed a whole flight of stairs, would be introduced into administrative procedure and this is unnecessary as a means of giving job status as an award for scientific achievement. It is difficult enough to arrive at an equitable

basis for determining relative salary at any given point in a research worker's career. To further determine whether he belongs in "associate" or in "senior" classification at a given age is adding an administrative load which may actually produce more ill will from those who don't make the grade and who think they should than the good will produced among the successful aspirants. It is, therefore, contended that this is an artificial administrative gimmick, which is unnecessary and undesirable in providing status for the deserving scientist.

Still another objection to a system of named and defined levels based on performance, merit, or contribution should be carefully considered: We can grade academic performance; we can agree upon Nobel Prize winners and other award winners in science, but where can the person be found who can put together a sequence of words that will adequately define, in a way that will have uniform application in research and development laboratories generally, a Senior Scientist, Senior Engineer, Associate Scientist, Associate Engineer, etc. It just cannot be done in any precise way. This should not surprise anyone when it is recognized that the differences between such classifications are matters of degree with no discontinuity between them.

In concluding the consideration of this subject, several observations and points of view may be emphasized.

1. Creative scientific and engineering work should have no artificial boundaries or fences.
2. In this work, the limits of an individual's creative ability determine his value and his contribution. The job description must recognize, ideally, that "the sky's the limit," and that the individual's ability determines how much he can accomplish and how far he can go.
3. Ladder classifications are not needed as a badge of status for the outstanding scientist or engineeer since there are other and better marks of recognition, such as freedom to publish or make speeches at symposia, meetings, etc., and

management interest, special authorizations, office accommodations, etc.

4. Ladders are convenient administrative mechanisms for financially rewarding outstanding people so designated. However, such people can be given the same pay treatment without ladders, so why risk the disadvantages of this unnecessary, complicated administrative structure.

Since the status and financial recognition of scientists and engineers can be achieved through a broad classification of individuals, it is the writer's conclusion that professional "ladders" are not needed, not wanted, and are a giant-sized administrative headache fraught with more dangers and disadvantages than benefits.